Chemistry 1506: Allied Health Chemistry 2

Section 5: Carboxylic Acids and Esters

Functional Groups with Single & Double Bonds to Oxygen

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Section 5.1 Introduction, Nomenclature, and Properties

- Generic Structure of Carboxylic Acid and Carboxylic Acid Derivatives

- Members of this Class
  - Carboxylic Acids
  - Esters
Acid Chlorides

Anhydrides

Amides
Physical Properties

Mp and Bp

taste and “feel”

Hydrogen Bonding

H-bond Donors

O-H and N-H

H-bond Acceptors

Lone pairs of O, N, and S

Directionally Specific

Hydrogen Bonds and Covalent Bonds
Relative Strengths of Intermolecular Bonds

- Van der Waals <
- Dipole - Dipole <
- Hydrogen Bonds <
- Covalent Bonds ≈ Ionic Bonds
Hydrogen Bonded Dimers of Carboxylic Acids

Apparent Doubling of MW

Cf. DNA

IUPAC Nomenclature of Carboxylic Acids

anoic acid (two words)

Examples
Section 5.2 Important Carboxylic Acids

- Formic Acid (Methanoic Acid)
  - Ants

- Acetic Acid (Ethanoic Acid)
  - Vinegar

- Oxalic Acid (dicarboxylic acid)
  - Rhubarb, Spinach, etc.

- Benzoic Acid
Section 5.3  Amino Acids having Carboxylic Acid Containing Side Chains

➢ Amino Acids (Building Blocks of Proteins)
➢ Generic AA = H₂N-CHR-CO₂H

➢ Aspartic Acid (acidic)
➢ R = CH₂C(=O)-OH

➢ Glutamic Acid (acidic)
➢ R = CH₂CH₂C(=O)-OH
Section 5.4 Biological Carboxylic Acids

➢ Fatty Acids

➢ R-CO₂H
Section 5.5 Preparation of Carboxylic Acids

- Oxidation Reactions
  - Oxidation of Aldehydes (Strong)
  - Oxidation of 1° Alcohols (Strong)
Section 5.6 Acid/Base Chemistry

- Equilibrium of Carboxylic Acids and Water
- Effects of the Electronegativity of R

- Carboxylic Acids plus Bases
  - Base = OH\(^-\), CO\(_3\)\(^{-2}\), HCO\(_3\)\(^-\), NR\(_3\), Pyridine, etc.
Nomenclature of Carboxylate Salts

- **Metal Alkanoate**
- **Examples**

Carboxylate Salts plus Acids

- **HCl, H₂SO₄**, etc.
Section 5.7 Esters

- Generic Structure

- Partial Charges on Carbon ($\delta^+$) and Oxygen ($\delta^-$)

- No Hydrogen-bonding with self

- H-bonding acceptor

- Physical Properties

- Mp and Bp

- Cf. Carboxylic Acids

- odor
Ethyl Acetate (Ethyl Ethanoate)

IUPAC Nomenclature

Alkyl Alkanoate

Examples
Section 5.8 Biological Esters

- Triglycerides

- Glycerol and Fatty Acids
Section 5.9 Ester Synthesis and Hydrolysis

- **Direct Esterification**
  - Uses $\text{H}^+$ catalyst

- **Direct Hydrolysis**
  - Uses $\text{H}_3\text{O}^+$ (i.e., $\text{H}^+$/H$_2$O)
Direct Esterification (easier)

- Via Acid Chlorides (Thionyl Chloride, SOCl₂)
  and Alcohols

- Alkanoyl Chlorides
Anhydride Routes to Esters

- Acetic Anhydride (only anhydride name for 506)

- Preparation via Acid Chloride plus Carboxylic Acid

- Anhydride plus Alcohol (easy)
Synthesis of “Polyester”

- Condensation Polymers
- Dacron, etc. Used in Fibers, Pop bottles, etc.

- PET, Poly(ethylene terephthalate)

- Terephthalic Acid plus Ethylene Glycol
Ester Hydrolysis

Hydrolysis by $\text{H}_3\text{O}^+$

Hydrolysis by $\text{OH}^-$

Soapoinification

Hydrolysis by lipase
Section 5.10  Phosphorous Acids and Esters

- $\text{H}_3\text{PO}_4$ neutralization
- Stepwise addition of OH$^-$
- $\text{H}_3\text{PO}_4$ alkylation
  - Addition of one equivalent of Alcohol
    - Cf. Carboxylic Acid reactions
    - Enzyme catalyzed gives monoalkyl phosphates

- Diesters and Triesters
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